The webinar will begin at 10:00 a.m. MST

Website
http://www.usbr.gov/pmts/materials_lab/

Corrosion and Coatings School
May 2015

Corrosion Webinar Series

June 2015
Suggest a topic!

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Managing Water in the West

Coatings Maintenance Assessments

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U.S. Department of the Interior
Bureau of Reclamation

Coatings Maintenance Assessments

Webinar Objectives

- Introduction to coatings
- Planning for a safe inspection
- Field inspection equipment & techniques
- Assessing coating condition & examples
- Hazardous materials sampling
- Coating maintenance options
- Developing maintenance plan & strategies

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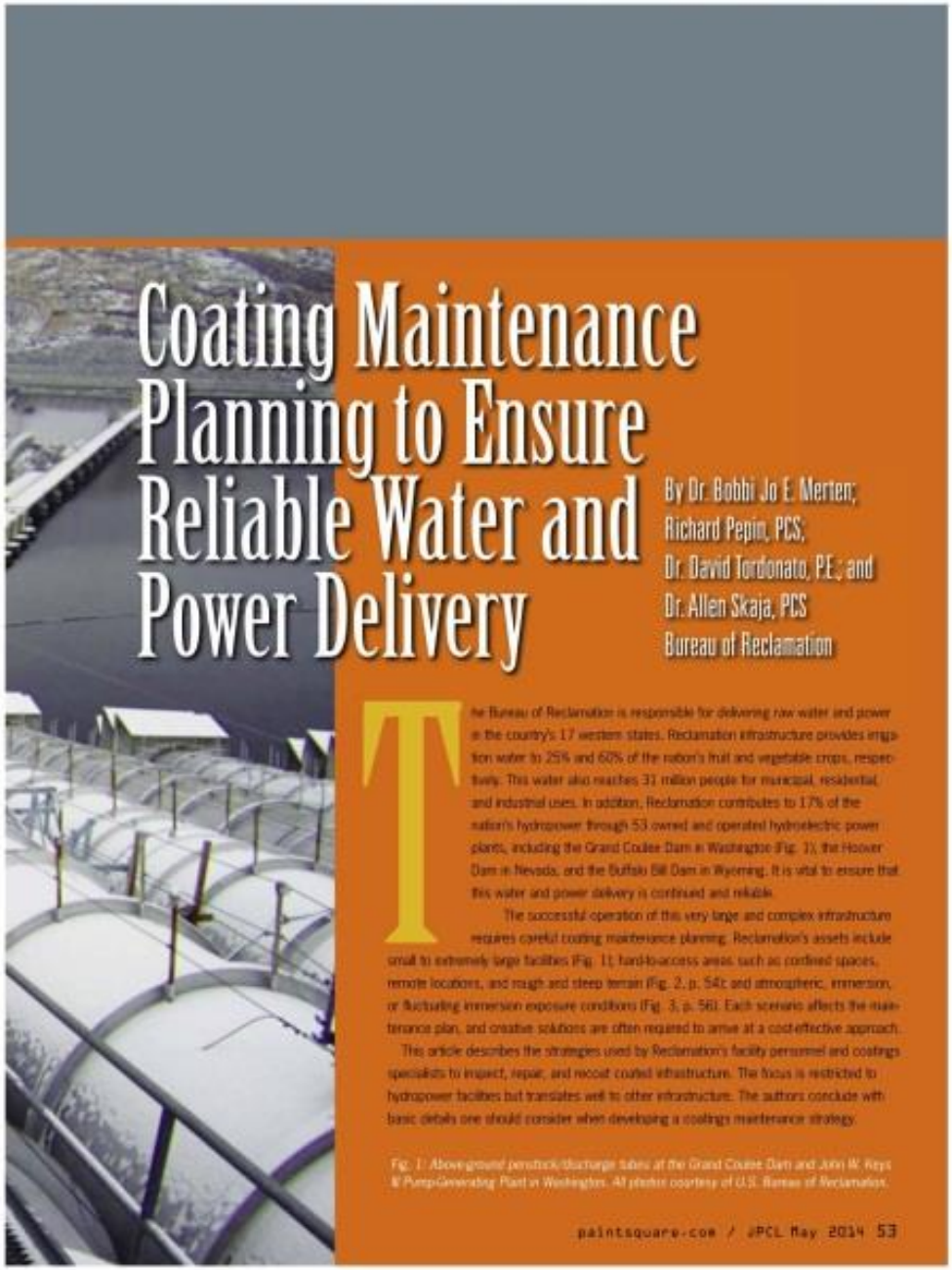
Based on:

2014 Journal of Protective Coatings and Linings (JPCL) Editors' Award



Coating Maintenance Planning to Ensure Reliable Water and Power Delivery

By Dr. Bobbi Jo E. Merten; Richard Pepin, PCS; Dr. David Tordonato, P.E.; and Dr. Allen Skaja, PCS
Bureau of Reclamation

The Bureau of Reclamation is responsible for delivering raw water and power in the country's 17 western states. Reclamation infrastructure provides irrigation water to 25% and 60% of the nation's fruit and vegetable crops, respectively. This water also reaches 31 million people for municipal, residential, and industrial uses. In addition, Reclamation contributes to 17% of the nation's hydropower through 53 owned and operated hydroelectric power plants, including the Grand Coulee Dam in Washington (Fig. 1), the Hoover Dam in Nevada, and the Buffalo Bill Dam in Wyoming. It is vital to ensure that this water and power delivery is continued and reliable.

The successful operation of this very large and complex infrastructure requires careful coating maintenance planning. Reclamation's assets include small to extremely large facilities (Fig. 1); hard-to-access areas such as confined spaces, remote locations, and rough and steep terrain (Fig. 2, p. 54); and atmospheric, immersion, or fluctuating immersion exposure conditions (Fig. 3, p. 56). Each scenario affects the maintenance plan, and creative solutions are often required to arrive at a cost-effective approach.

This article describes the strategies used by Reclamation's facility personnel and coatings specialists to inspect, repair, and recoat coated infrastructure. The focus is restricted to hydropower facilities but translates well to other infrastructure. The authors conclude with basic details one should consider when developing a coatings maintenance strategy.

Fig. 1: Aboveground penstock/discharge tubes at the Grand Coulee Dam and John W. Keys III Pump/Generating Plant in Washington. All photos courtesy of U.S. Bureau of Reclamation.

Introduction to Paints & Coatings

- Ancient history*
  - 100,000 BC: ochre-based mixture—paint?
  - 40,000 BC: cave paintings drawn with red or yellow ochre, charcoal, other pigments
- Today's paints / coatings
  - Architectural paints (latex house paints)
  - Concrete sealers (basements, driveways)
- Protective coatings: robust properties
  - Strong adhesion to the substrate
  - Controlled penetration of water and ions

*http://en.wikipedia.org/wiki/Paint

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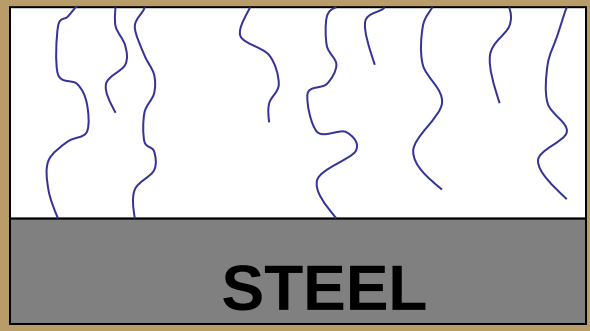
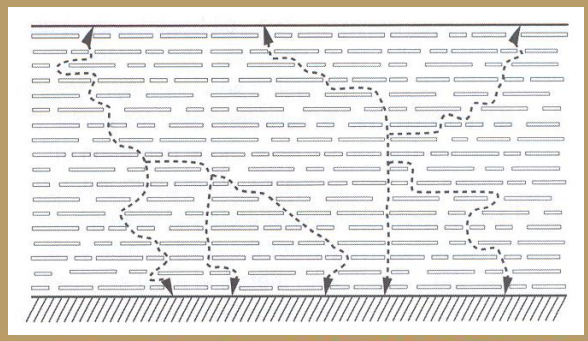
Introduction to Protective Coatings

Thermoplastic	Thermoset
One container	Two or more containers; except moisture-cured urethanes & siloxanes and alkyds
“Dries” as solvents evaporate	“Cures” by chemical reaction
Vinyl, coal tar enamel, latex	Epoxy, polyurethane, coal tar epoxy, alkyd

- **Paint (coating) = binder (polymer) + pigment & filler + solvent or diluent**
- **Barrier coatings are most common**
  - **High film build (coal tar enamel, polyurethane, epoxy)**
  - **Flake pigments to make tortuous path for water (aluminum, glass, etc.)**
- **Sacrificial (zinc-rich, metallizing)**
- **Inhibitive (lead, chromate)**





Historical Coatings Used By Reclamation

- Coal tar enamel (still available, but limited application)
- CA-50 cold applied coal tar paint
- Red lead primer + phenolic aluminum topcoat
- Vinyl resins, VR-3, VR-6, VR-M
- Coal tar epoxy (still in use)

Phenolic lead + aluminum

CA-50

VR-6

Planning for a Safe Inspection

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Planning a Safe Inspection

- **Certifications**
  - **Fall protection (possibly rope access)**
  - **Confined space, permit required**
  - **Lock out tag out (LOTO) (*now hazardous energy control program* (*HECP*))**
- **Job hazard analysis (JHA) other considerations**
  - **Weather**
  - **Wildlife**
  - **Safety shoes, hard hats, hearing protection, other personal protective equipment (PPE)**
  - **Loose clothing**
  - **Coating sampling for hazardous materials**

Potential Inspection Conditions






Partially-filled pipes (sand or water), rope access or fall protections techniques, poor weather, animals, and severely degraded infrastructure are possible

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Field Inspection Equipment & Techniques

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Inspection Survey Types

- General visual: non-quantitative
  - Determine one of two parameters:
    - Condition (good, fair, or poor)
    - Rust rating (ASTM D 610)
  - Normally completed in a few hours
  - Suitable to distinguish severe conditions

- Detailed visual: semi-quantitative
  - Systematic survey of structural elements – support beams, connections, edges, etc.
  - Document reduced film thickness, coating deterioration, rust on edges or flat surface, and severe corrosion or metal loss

Inspection Survey Types – cont.

- **Physical inspection survey: physical properties / destructive**
  - **Adhesion (ASTM D 3359, D 4541, or knife)**
  - **Film thickness (Tooke gauge) & number of coats**
  - **Sample paint chip (more on this later…)**

- **Helpful hints**
  - **Hold light source close to pipe wall to scan for raised blisters**
  - **Use mirrors to see around corners or hard to reach areas**
  - **Use binoculars or a good camera to see distances close-up**

References – Inspection Standards

- SSPC – Vis 2
- ASTM D 610 - Standard Practice for Evaluating Degree of Rusting on Painted Steel Surfaces
- ASTM D3359 - Standard Test Methods for Measuring Adhesion by Tape Test
- ASTM D4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
- SSPC – PA 2 how to measure the dry film thickness (DFT) of coatings
- ASTM D1005 - Standard Test Method for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers
- ASTM E213 - Standard Practice for Ultrasonic Testing of Metal Pipe and Tubing
- ASTM E1444/E1444M - Standard Practice for Magnetic Particle Testing
- ASTM E709 - Guide for Magnetic Particle Testing Examination

Assessing Coating Condition & Examples

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Maintenance Inspections

- Things to consider
  - Previous repairs, problem areas, construction challenges (limited outage, confined space, seepage control, etc.)
  - Coating condition—visual defects, film and ultrasonic thickness testing, hazardous materials testing
  - Service Conditions: atmospheric, burial, or immersion

- Maintenance options
  - Several may be feasible
  - Include funding perspective from facility owner

- Collect sample for hazardous materials if maintenance is likely

Common Adverse Conditions

Chalking

Cracking

Blistering

Uniform degradation

Galvanic Corrosion

Typical Problem Areas

Drips

Splash zone

Water spray around leaking seal

Turbine runners & draft tube

Aged Coal Tar Enamel

Alligator cracking

Heat differential (enters soil)

Brittle failure at rivet

Corrosion at joint

Aged Epoxy Coating

Problem areas requiring repair

Typical condition of structure →

Hazardous Materials Sampling

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Assessing Coating Harzards

Asbestos

- Assume the existing coating contains hazardous material
  - Use appropriate PPE
    - Inhalation (breathing) – dust and fumes
    - Ingestion (eating)
  - Collect coating samples
    - Use sampling plan to document sampling and analysis
    - Use appropriate methods and laboratories
- Include test results in specification or statement of work
  - Do not assume level is too low to include in contract (include non-detects)
  - “Detectable” is any level above the method detection limit

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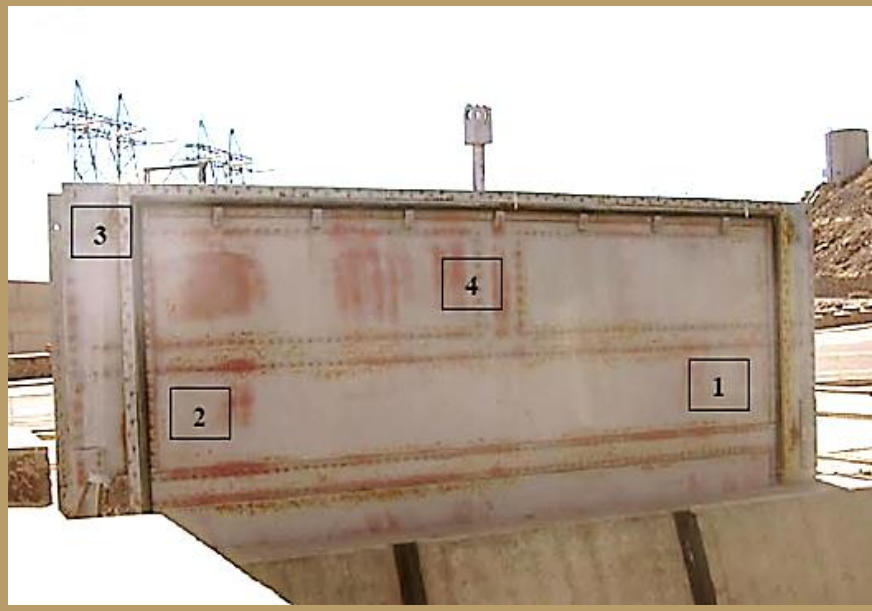
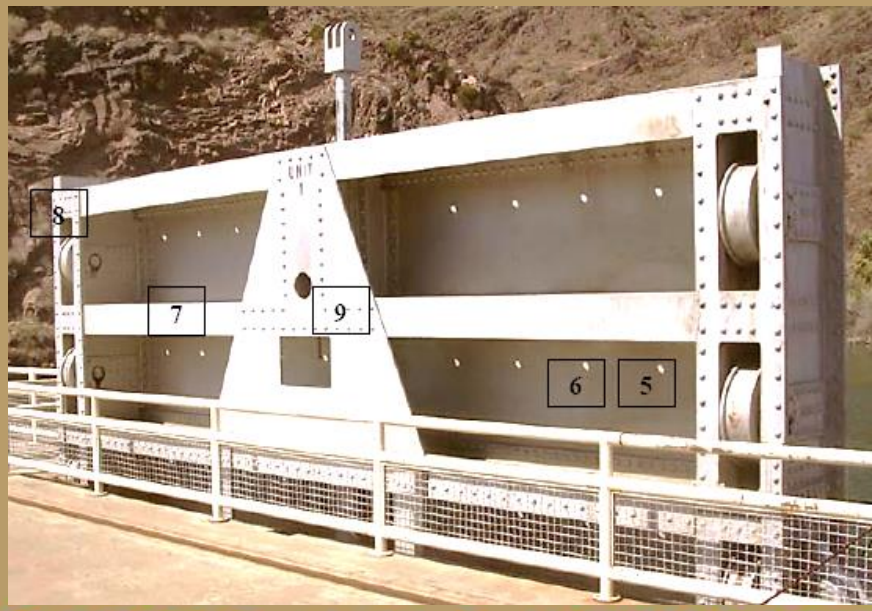
Sampling Plan

- Sample several areas for each coating and create a composite
- Indicate exact sample locations (diagram, pictures, etc.)
- Use chain of custody procedure
- Methods (EPA, ASTM, NIOSH)
- Hazards to test for
  - Metals—lead, chromate, cadmium, arsenic, mercury, barium, selenium, silver
  - Non-metals—coal tar pitch, asbestos, polychlorinated biphenyls (PCBs), silicates





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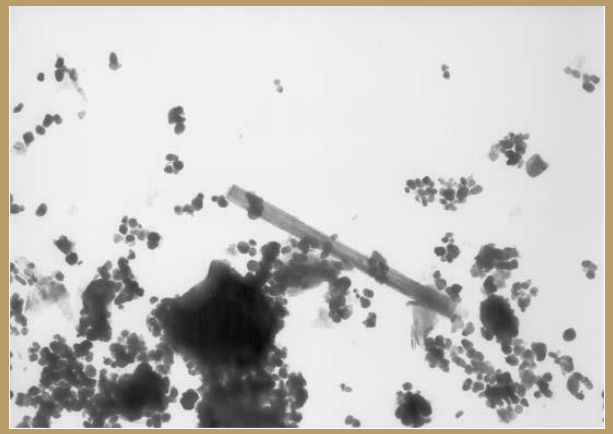
Sample Size & Approximate Cost

- **RCRA 8 Metals, EPA SW846 6010/6020**
  - **Size: 5 grams**
  - **Cost: $150/sample; $15/metal if over ten metals**
- **Asbestos, EPA 600/R-93/116**
  - **Used in coatings, plasters, putty, and caulks**
  - **Size: – 2 square inches (all layers & types of surface represented)**
  - **Cost: $25/sample PLM bulk; $200/sample TEM**
- **PCB, EPA SW846 8082**
  - **Used in hundreds of industrial and commercial applications including as plasticizers and pigments in paints (vinyl, lead primers, aluminum topcoats, coal tar enamel)**
  - **Size: 30 grams**
  - **Cost: $80 to $140**



Asbestos-like fiber

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References – Hazardous Materials Sampling

Regulations

- **Clean Water Act – www.epa.gov/r5water/cwa.htm**
- **Clean Air Act – www.epa.gov/oar/caa/**
- **CERCLA – www.epa.gov/superfund/action/law/cercla.htm**
- **TSCA – www.epa.gov/Region5/defs/html/tsca**
- **RCRA – www.epa.gov/region5/defs/html/rcra.htm**
- **OSHA – www.osha.gov/**

Training (all SSPC)

- **C3 – Supervisor / competent person training for deleading of industrial structures**
- **QP2 – Certification program (field removal of hazardous coatings)**
- **Guide 6 – Containing surface preparation debris generated during paint removal operations**
- **QP4 – Evaluating the qualifications of contractors disturbing hazardous coatings during demolition and repair work**
- **TU 7 – Conducting ambient air, soil, and water sampling during surface preparation and paint disturbance activities**

Bureau of Reclamation contacts

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- **Allen Skaja, 303-445-2396, askaja@usbr.gov**

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Coating Maintenance Options

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Maintenance Painting Options

- No painting
  - Deferral of maintenance
  - Decommission planned
- Spot repairs
- Spot repairs & full overcoat
- Total removal and recoat
- Alternatives / additions
  - Install cathodic protection
  - Replacement (in kind, plastics, composites, etc.)

- Progressively increase in complexity, work, & expense

See SSPC- Guide 5 Maintenance Painting Program

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Deferral of Maintenance

- Coating is in good condition
- Structure's service life is limited
- Full recoat almost required (> 10% damage)
- Full recoat required but allocate funds to maintaining other coatings
- A contributing deficiency must be resolved first (example: control leaks, seepage, or drips)

Fix seepage!

Fix leaks!

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Spot Repairs

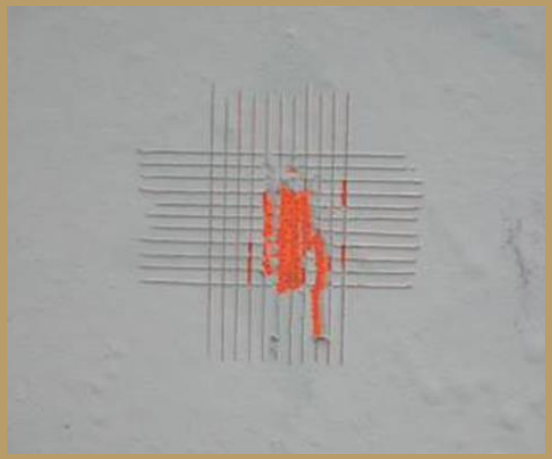
- Document or approximate the number of repairs needed
  - May be cost prohibitive at > 15% of area
  - Add a few inches around perimeter to feather
- Where do you draw the line?

Spot Repair with Full Overcoat(s)

- Not recommended if existing coating is embrittled, flaking, cracking or loose (minimal adhesion)

- Assess existing coating
  - Thickness, age, type of coating, number of coats, chalking, adhesion, cohesion, surface contaminants, amount of rust
  - Test coating compatibility via test patches (ASTM D 5064)
  - For atmospheric exposure only!

- Drawbacks
  - Coating failure is possible
  - Lead remains on structure



See SSPC TU 3 – Overcoating

Total Removal and Recoat

- Economical for > 15% repairs (rule of thumb)
- Restarts maintenance cycle

Coal tar enamel lining (70+ years)

Coal tar enamel lining

Corrosion cell

Ideal Maintenance Cycle

1. Total removal and replacement starts the new cycle
2. Several rounds of spot repairs
3. Spot repair with full overcoat (except immersion)
4. Coating adhesion degrades to the point where addition repairs are no longer practical

Example:

Year	Action
0	Initial painting
8	Spot repair
12	Spot repair
16	Spot repair + overcoat
22	Full recoat

Cathodic protection can extend service life in some circumstances

See NACE 2008, Paper 08279

Progression of Maintenance Project

- **Scope definition**
  - **What items will receive painting maintenance?**
  - **What items must be protected or treated separately?**
    - **Mating and machined surfaces**
    - **Mechanical or electrical equipment**
    - **Instruction and similar plates**
- **Coatings specification**
  - **Guide specification available online**
  - **Contract TSC for services**
- **Construction Support : Quality Assurance (NACE CIP or similar)**

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Developing Maintenance Plan & Strategies

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Developing a Maintenance Strategy

- **Funding**
  - **What is the funding source for maintenance?**
  - **Does it cover regular inspections, repairs, and replacement?**
- **Infrastructure**
  - **What type of infrastructure requires protection?**
  - **Is it a single substrate type such as steel, concrete, etc.?**

Structure is a steel liner in immersion exposure

Developing a Maintenance Strategy Cont.

- Exposure – what exposure(s) does it receive?
- Special construction needs
  - What is the accessibility? Confined space? Strict outages?
  - Can it be recoated without interrupting operations?
  - Does the present coating contain hazardous materials?

Structure has intermittent immersion and UV exposure

Challenge is to maintain over water source

Thank you for your attention! Questions?

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